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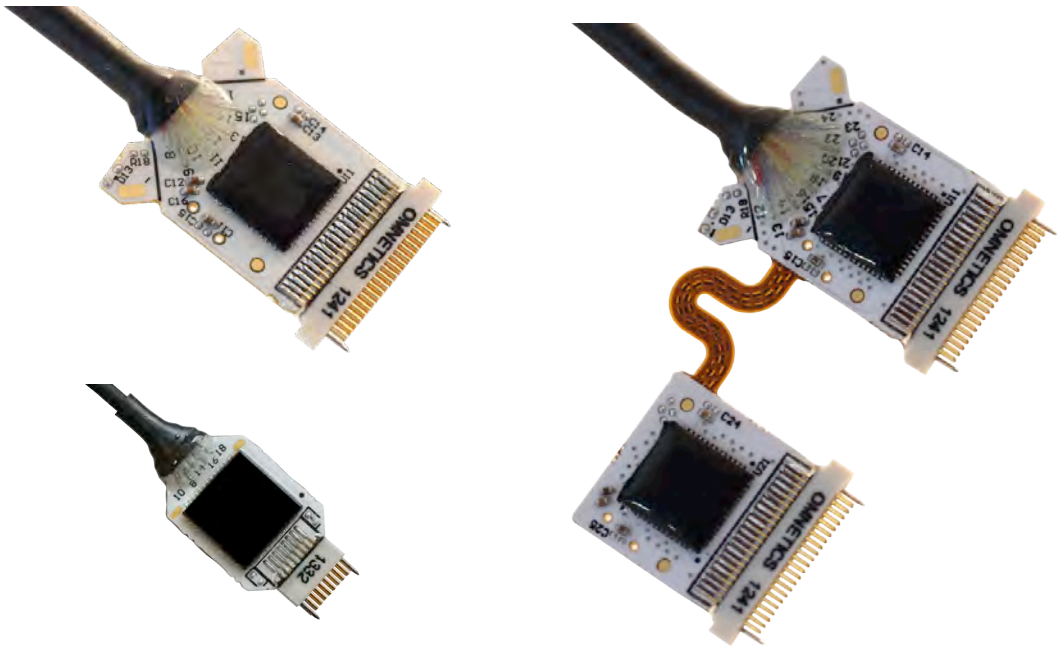

HS-xx-mux

User's Manual

Multiplexing Headstage that allows recording on 16 to 64 individual electrodes

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1 Document Overview

This document describes the specifications and features of the multiplexing headstage. It also explains how to set up your headstage, test it, and use it during normal operation. There is a glossary at the end of the document.

2 Multiplexing Headstage Overview

This HS-xx-mux is a multiplexing headstage that records from up to 64 individual electrodes. The physiological signals are digitized at the headstage, which allows the required number of cable conductors to be greatly reduced.

Features:

- Versions include the HS-16-mux, the HS-32-mux and the HS-64-mux.
- ±5mV Input Range.
- >80dB Common Mode Rejection Ratio(CMRR) at 60Hz.
- <2.5μV_{RMS} Noise (0.1Hz to 9kHz).
- Interfaces directly with Digital Lynx SX.
- 25 Conductor Cable transfers up to 64 channels to Digital Lynx SX.
- Up to 128 Digital Channels per Digital Lynx SX.
- Compatible with Neuralynx EIBs.

2.1 Important Note

The multiplexing headstage must be connected to the Digital Lynx SX before the system is powered ON. Otherwise the system won't recognize that a multiplexing headstage is present.

3 What's included with the multiplexing headstage?

There are three different channel counts available as a multiplexing headstage, the HS-16-mux, the HS-32-mux and the HS-64-mux. Both arrive already soldered to the tether, with the TETH-multiplexing headstage as an extension.

3.1 HS-64-mux

- 64 Channels digitized on the headstage.
- 2 Static References, one per bank of 32 channels.
- Compatible with HS-36 Series EIBs.
- Standard 2 meter tether.
- 5.0 grams.

Figure 3-1 HS-64-mux

3.2 HS-32-mux

- 32 Channels digitized on the headstage.
- 1 Static Reference for all 32 channels.
- Compatible with HS-36 Series EIBs.
- Standard 2 meter tether.
- 4.0 grams.

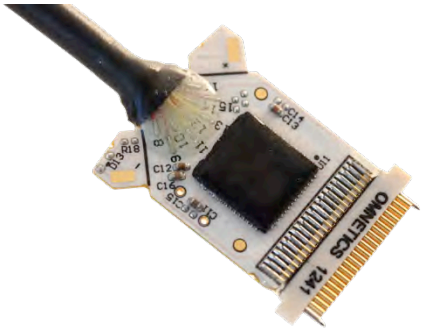


Figure 3-2 HS-32-mux

3.3 HS-16-mux

- 16 Channels digitized on the headstage.
- 1 Static Reference for all 16 channels.
- Compatible with HS-16 and HS-18 Series EIBs.
- Standard 2 meter tether.
- 1.3 grams
- Can we ordered with or without video tracking LED ears.

Figure 3-3 HS-16-mux

3.4 TETH-mux headstage

- Compatible with any multiplexing headstage.
- Standard 1.5 meter tether.

Figure 3-4 TETH-mux headstage

3.5 ADPT-DUAL-HS-MUX

- Allows two HS-32-mux or two HS-16-mux to connect to a single port on the Digital Lynx SX.

Figure 3-5 ADPT-DUAL-HS-MUX

3.6 Additional Testing Items

Additionally, a Signal Mouse (SM-32/64) and an Impedance Plug (HS-36 Impedance Plug), can be purchased as separate items for testing the signal through the multiplexing headstage and the Digital Lynx SX.

3.6.1 SM-32/64

- Interface for driving test signals into the multiplexing headstage.
- Switches control Bank 1, Bank 2, Bank 3, Bank 4, and the Reference.

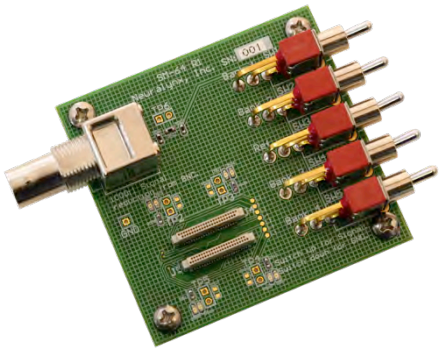


Figure 3-6 SM-64

3.6.2 HS-36 Impedance Plug

- Test plug with different resistance values on each bank of eight channels.

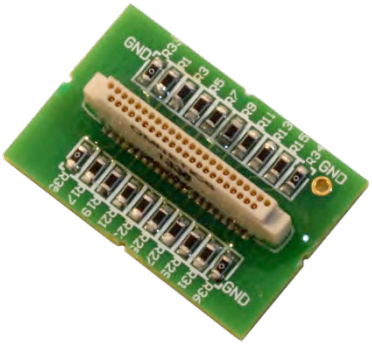


Figure 3-7 HS-36 Impedance Plug

3.6.3 HS-16-mux Impedance Plug

- Test plug with different resistance values on each bank of four channels.

Figure 3-8 HS-16-mux Impedance Plug

3.6.4 HS-16-mux Video Tracking LEDs

- Omni-directional Video Tracking LEDs.
- Color Options: Red, Blue, and Green.

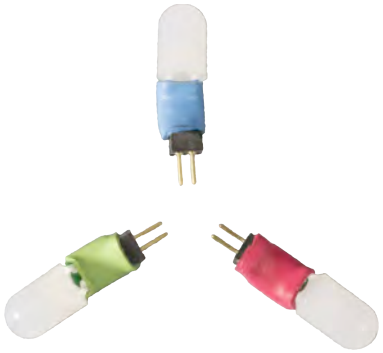


Figure 3-9 HS-16-mux Video Tracking LEDs

3.7 Electrostatic Sensitive Equipment

All Neuralynx Equipment is Electrostatic Sensitive and should be handled with appropriate measures. Always wear a static strap and use all appropriate ESD measures when handling any electronics. Please contact Neuralynx for detailed information if you have questions.

4 Quick Start

The following instructions are provided to quickly set up and test your multiplexing headstage setup. If your Digital Lynx SX system requires the upgrade for compatibility with the multiplexing headstage, please see the Digital Lynx SX HS Multiplexer Upgrade User Manual.

4.1 Multiplexing Headstage Setup

The multiplexing headstage connects to the Digital Lynx SX in a different way than a standard Neuralynx Analog Headstage. Instead of connecting to a DRS-36 Board or an Input Board, the multiplexing headstage connects to the Digital Lynx SX Motherboard. The multiplexing headstage connections are illustrated and described below.

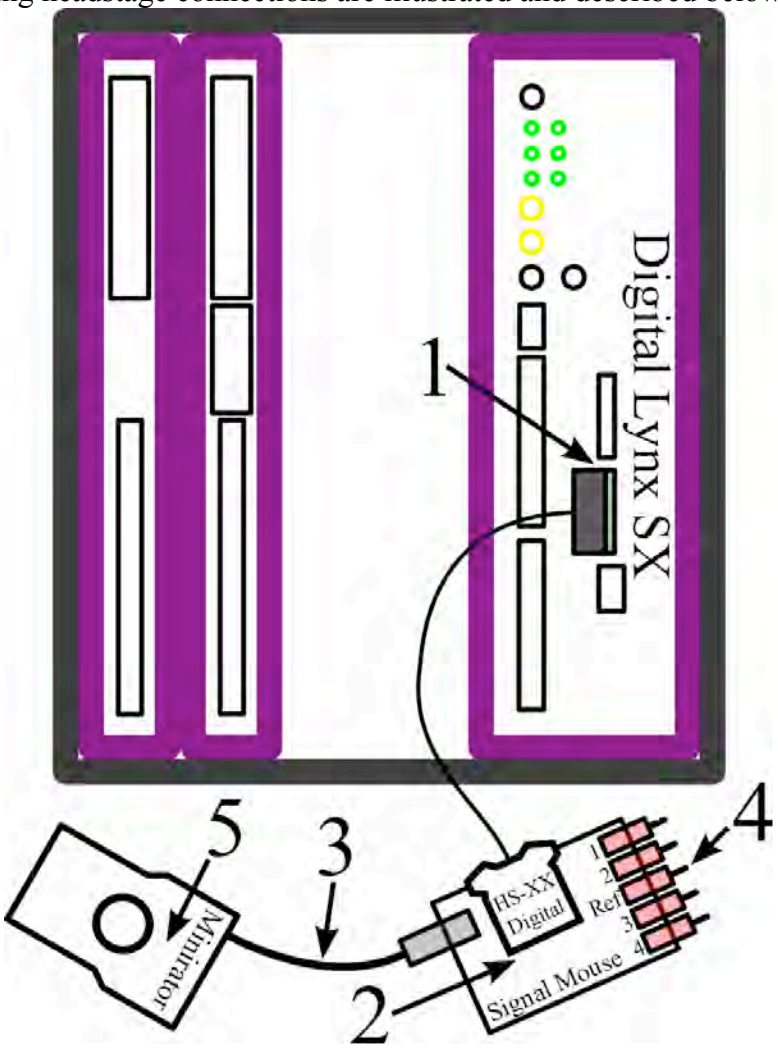


Figure 4-1 Hardware Connections

Connections:

1. Connect the multiplexing headstage to the connector labeled *1* on the Digital Lynx SX Motherboard.

a. NOTE: The multiplexing headstage must be connected to the Digital Lynx SX before the system is powered ON. Otherwise the system won't recognize that a multiplexing headstage is present.

2. Connect the multiplexing headstage to the SM-64.
3. Connect the Minirator, or other signal source, to the SM-64 using a BNC Cable.
4. Turn the Bank 1, 2, 3, and 4 switches on the SM-64to the Signal Position (Up). Turn the Reference switch on the SM-64 to the Ground Position (Down).
5. Set the Minirator, or other signal source, to output a $1V_{PP}$ Sine Wave at 100 Hz. The SM-64 will reduce this signal to roughly to $1mV_{PP}$.
6. Power the Digital Lynx SX ON.

4.2 Start Cheetah

In Digital Lynx SX Systems that already contain Input Boards, it is important to note that the AD Channels associated with the multiplexing headstage begin after the last Input Board AD Channel. This concept is illustrated in the table below. This table assumes one multiplexing headstage is being used. The maximum channel count of the Digital Lynx SX System is 512 Channels

Number of Input Boards	HS-64 Digital Starting AD Channel	Total Channel Count
0	0	64
1	32	96
2	64	128
3	96	160
4	128	192
5	160	224
6	192	256
7	224	288
8	256	320
9	288	352
10	320	384
11	352	416
12	384	448
13	416	480
14	448	512

Figure 4-2 Multiplexing Headstage Starting AD Channel

4.2.1 Configure Cheetah with the Proper Configuration

Power On the Digital Lynx SX and wait for boot cycle to complete. On the Computer open the Cheetah Configuration Folder. Modify your preferred Configuration File to allow the multiplexing headstage AD Channels to be sent to Cheetah. On the Desktop select the *Run Cheetah* shortcut to open the Cheetah Welcome Screen. Boot Cheetah with a modified configuration file for your new setup. In this example 32 CSCs are used.

4.3 Drive Signal into the Multiplexing Headstage

In Cheetah, select the *ACQ* Button to Start Acquisition. Set the Input Range for all 32 CSCs to 1000µV and set the Reference for all 32 CSCs to Reference 1. Observe the 32 CSCs. Each should show a reduced (roughly $1mV_{PP}$) version of the Minirator output. Refer to the figure below.

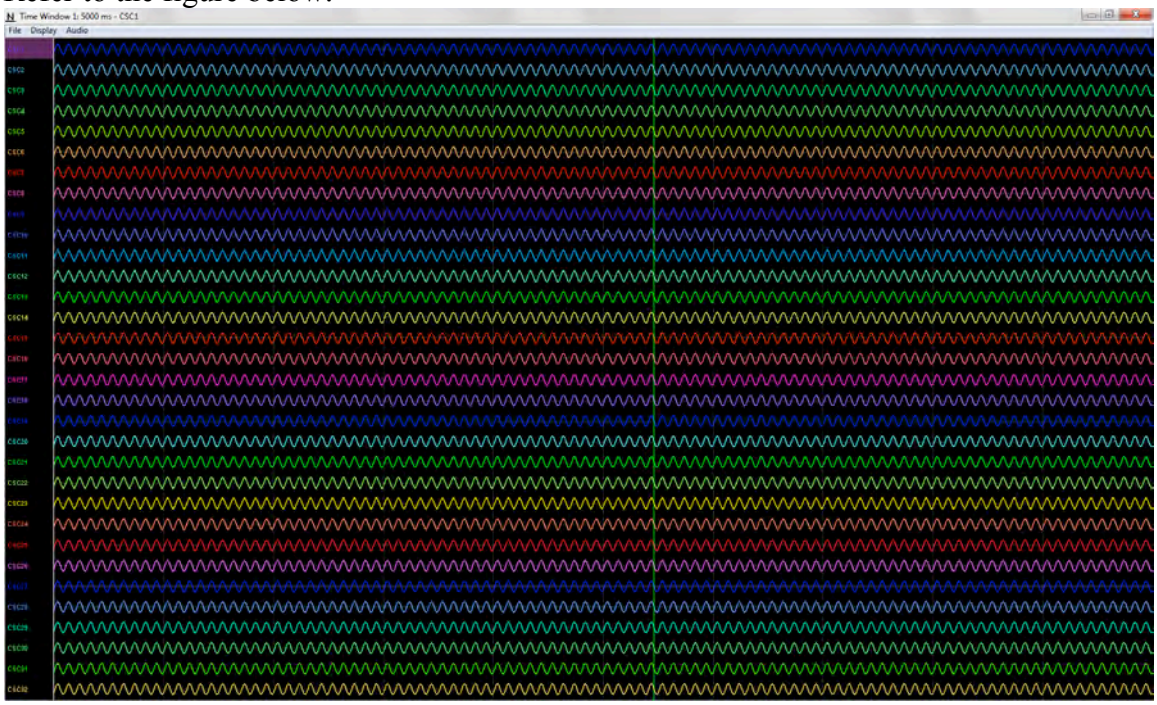


Figure 4-3 Bank 1, 2, 3 and 4 Switches Up. Reference Switch Down.

Switch the Bank 1 Switch to the Ground Position (Down). Observe the 32 CSCs. CSCs 1-8 should now be flatlined while CSCs 9-32 still shows a reduced (roughly $1mV_{PP}$) version of the Minirator output. Refer to the figure below.

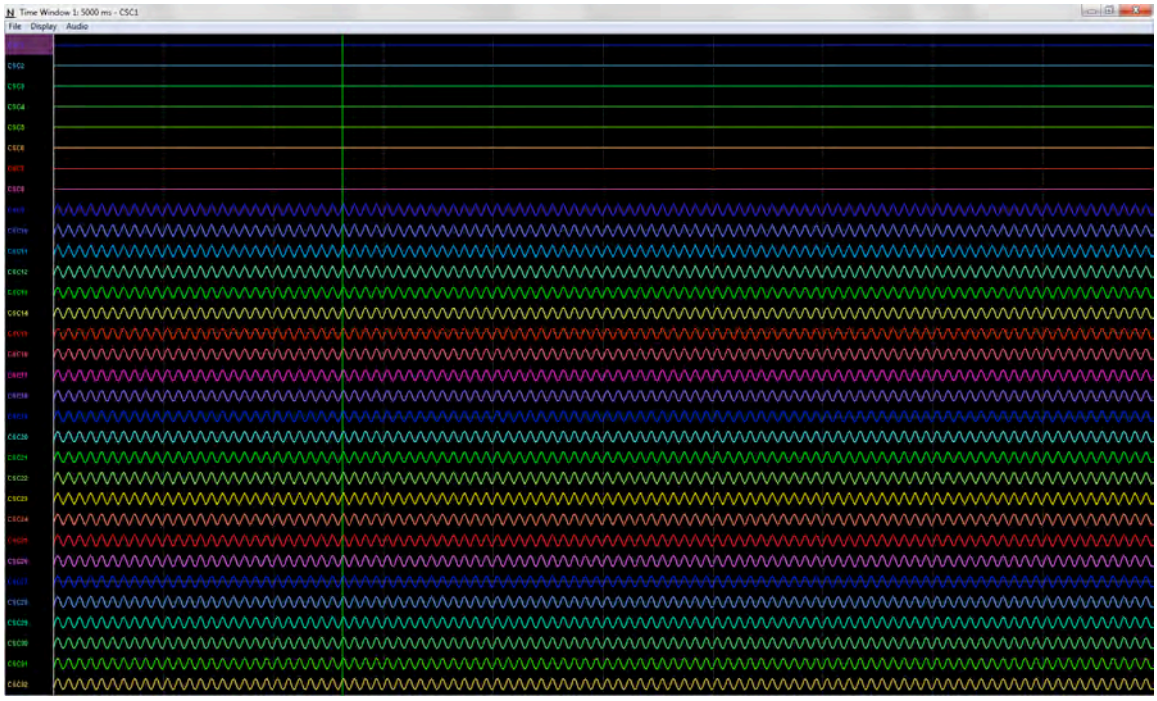


Figure 4-4 Bank 2, 3 and 4 Switches Up. Bank 1 and Reference Switches Down.

Switch the Bank 2 Switch to the Ground Position (Down). Observe the 32 CSCs. CSCs 1-16 should now be flatlined while CSCs 17-32 still show a reduced (roughly $1mV_{PP}$) version of the Minirator output. Refer to the figure below.

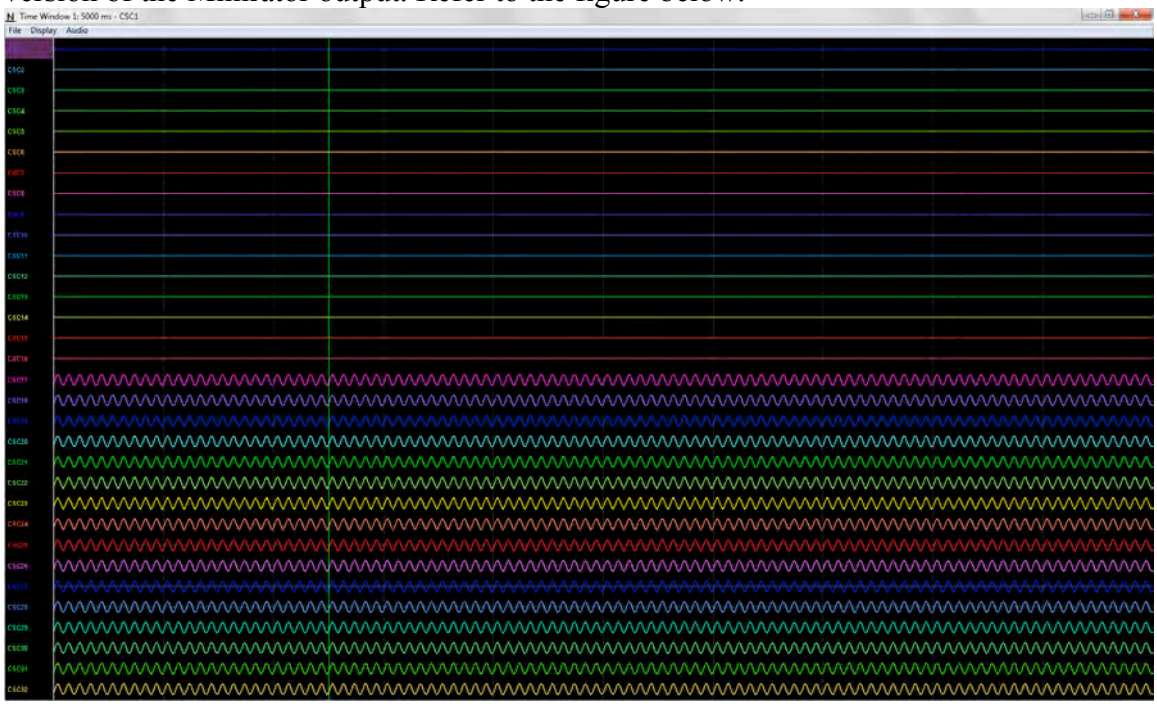


Figure 4-5 Bank 3 and 4 Switches Up. Bank 1, 2 and Reference Switches Down.

Switch the Bank 3 Switch to the Ground Position (Down). Observe the 32 CSCs. CSCs 1-24 should now be flatlined while CSCs 25-32 still show a reduced (roughly $1mV_{PP}$) version of the Minirator output. Refer to the figure below.

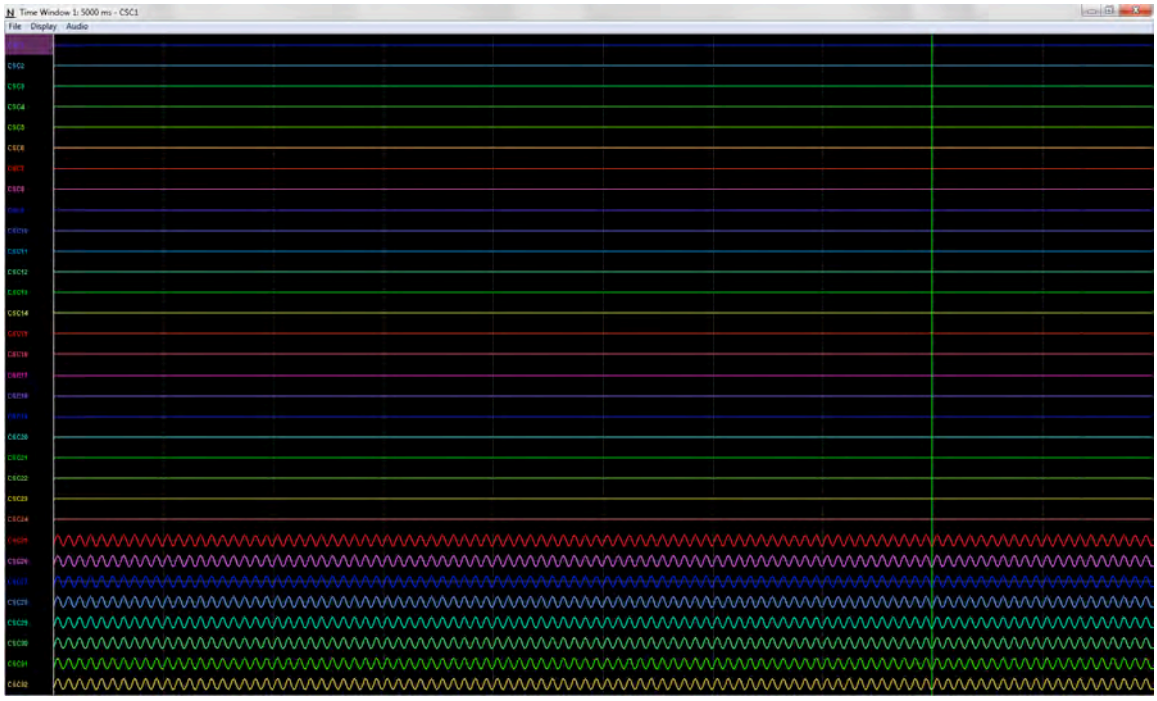


Figure 4-6 Bank 4 Switches Up. Bank 1, 2, 3 and Reference Switches Down.

Switch the Bank 4 Switch to the Ground Position (Down). Observe the 32 CSCs. CSCs 1-32 should now be flatlined. Refer to the figure below.

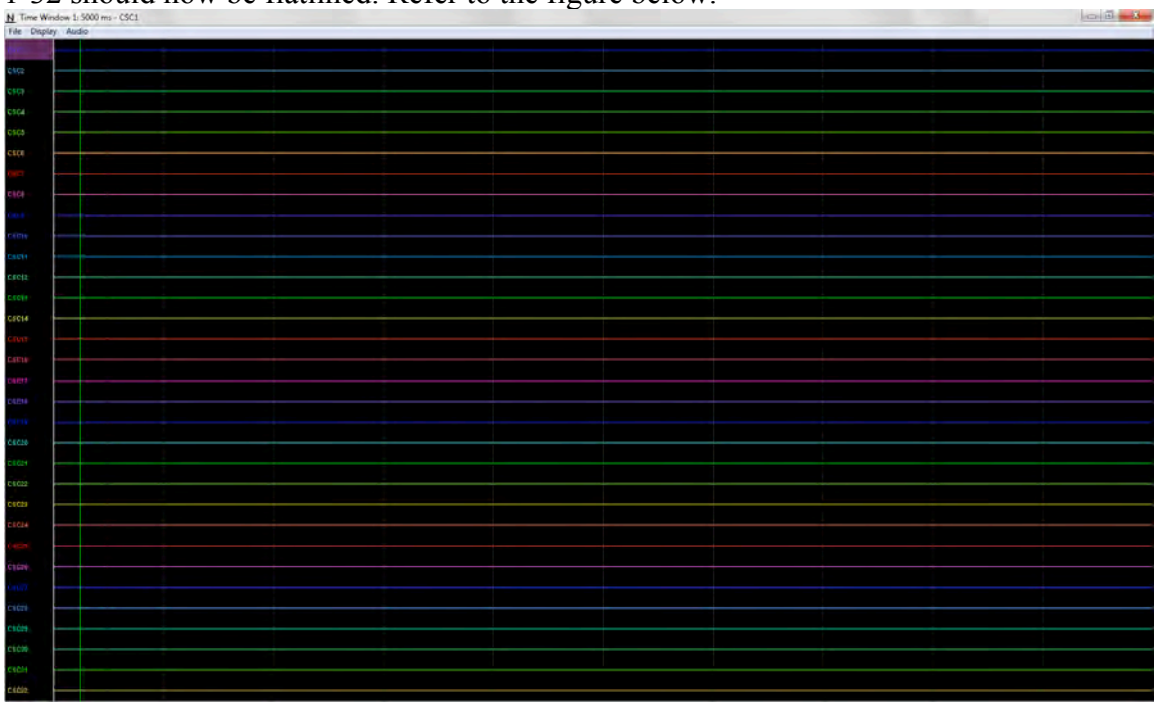


Figure 4-7 All Switches Down (1000µV).

Set the Input Range for all 32 CSCs to 25µV. Observe the 32 CSCs. CSCs 1-32 now show the baseline noise. Each should be less than 25µVpp and void of any repetitive signals. Refer to the figure below.

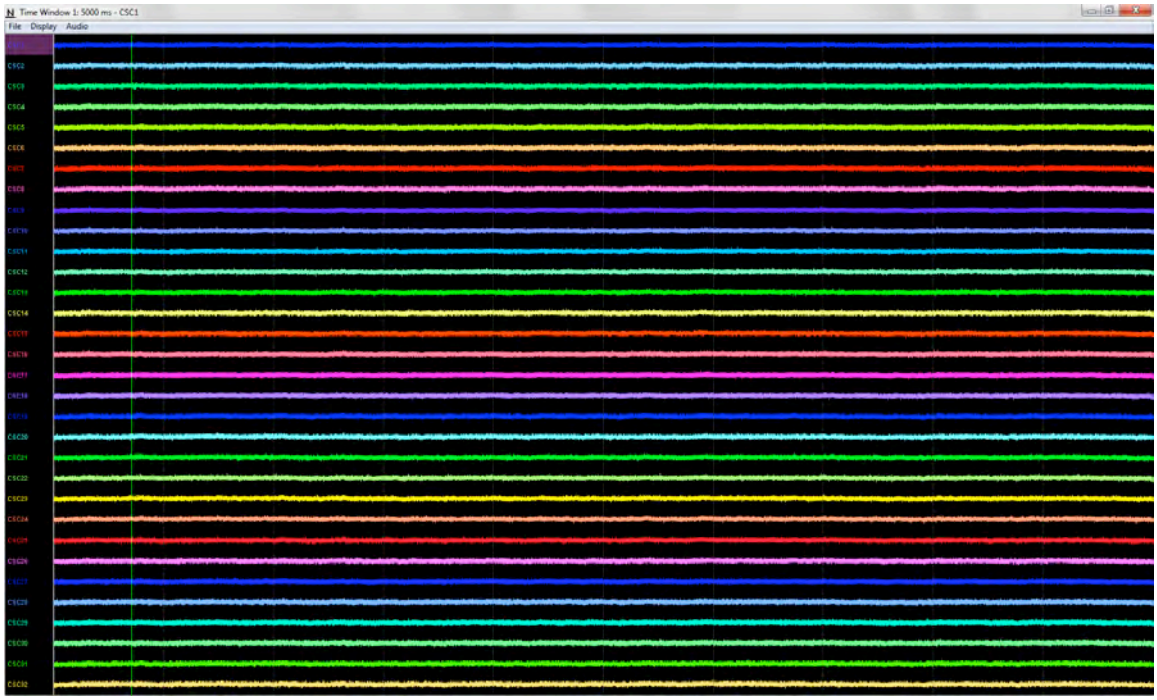


Figure 4-8 All Switches Down (25µV).

Switch all the Switches to the Signal Position (Up). Observe the 32 CSCs. Each should be less than 25µVpp and void of any repetitive signals. Refer to the figure below.

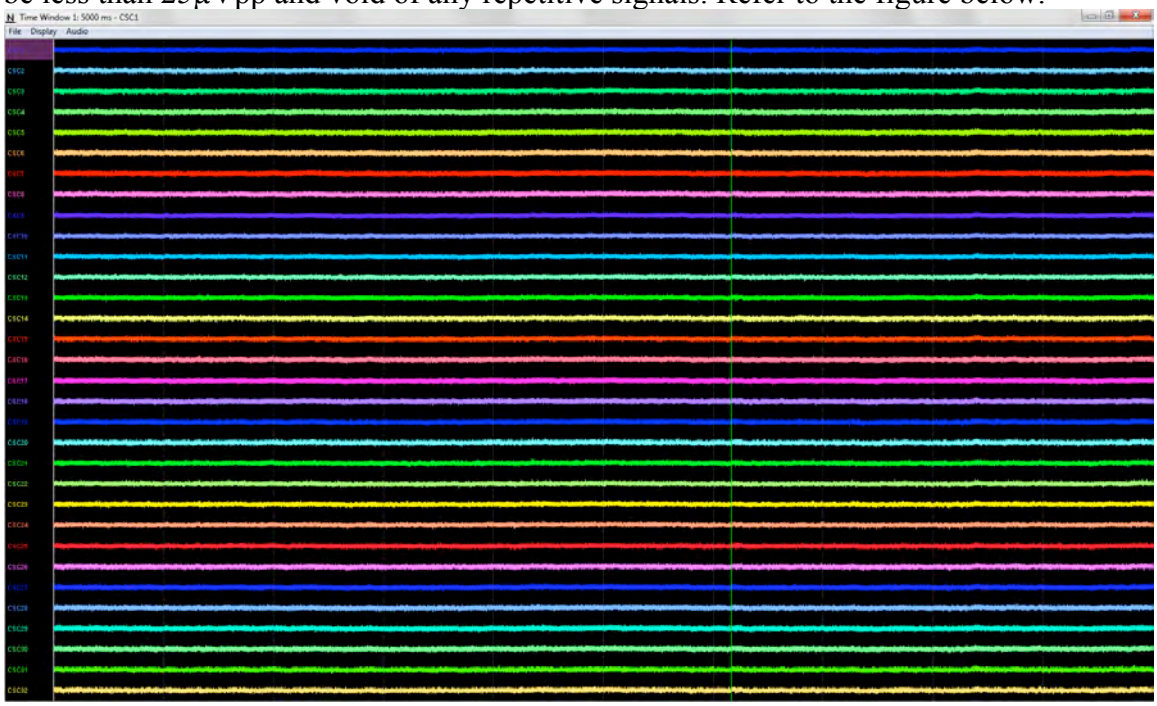


Figure 4-9 All Switches Up (25µV).

4.4 Performing an Impedance Test

The multiplexing headstage contains an internal AC current waveform generator that can output 9 different current amplitudes at 1kHz. The AC current waveform generator is controlled by sending specific commands to the Digital Lynx SX, which are then routed

to the multiplexing headstage. These commands can be sent through a NetCom interface or simply through a Cheetah Configuration File. All Multiplexing Headstage Commands and their syntax are discussed in **Section 6 Multiplexing Headstage Command Descriptions**. To begin the multiplexing headstage needs to be connected to the HS-36 Impedance Plug.

Connections:

1. Disconnect the multiplexing headstage from the SM-64.
2. Connect the multiplexing headstage to the HS-36 Impedance Plug.

In this example we will use a Cheetah Configuration File to perform an impedance test on Channel 25 of a multiplexing headstage using the following sequence of events (this assumes all the hardware is still connected as shown in **Section 4.1 Multiplexing Headstage Setup**):

Command Sequence:

1. Set the Impedance Measurement Channel to 25.
2. Set the Impedance Measurement Current to 3.85nA (The Current Options for this command are listed in **Section 6 Multiplexing Headstage Command Descriptions**, 3.85nA is option number 6).
3. Enable the Impedance Measurement Function.

Using the commands and syntax discussed in **Section 6 Multiplexing Headstage Command Descriptions** the following configuration file can be created.

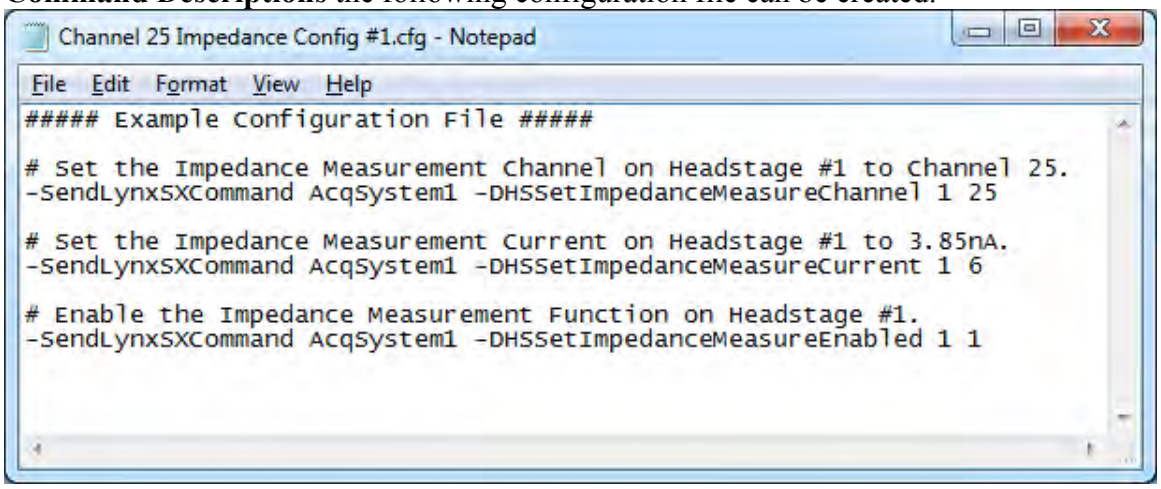

Channel 25 Impedance Config #1.cfg - Notepad
File Edit Format View Help
Example Configuration File
Set the Impedance Measurement Channel on Headstage #1 to Channel 25.
-SendLynxSXCommand AcqSystem1 -DHSSetImpedanceMeasureChannel 1 25
Set the Impedance Measurement Current on Headstage #1 to 3.85nA.
-SendLynxSXCommand AcqSystem1 -DHSSetImpedanceMeasureCurrent 1 6
Enable the Impedance Measurement Function on Headstage #1.
-SendLynxSXCommand AcqSystem1 -DHSSetImpedanceMeasureEnabled 1 1

Figure 4-10 Example Configuration File

Once the configuration file has been created and saved it can be run in Cheetah by selecting *File > Open Configuration File*. Browse to the configuration file selected *Open*. The configuration file will immediately execute. Observe CSC 25 in Cheetah, it should show a 1000Hz sine wave roughly 750mV$_{PP}$. Refer to the figure below.

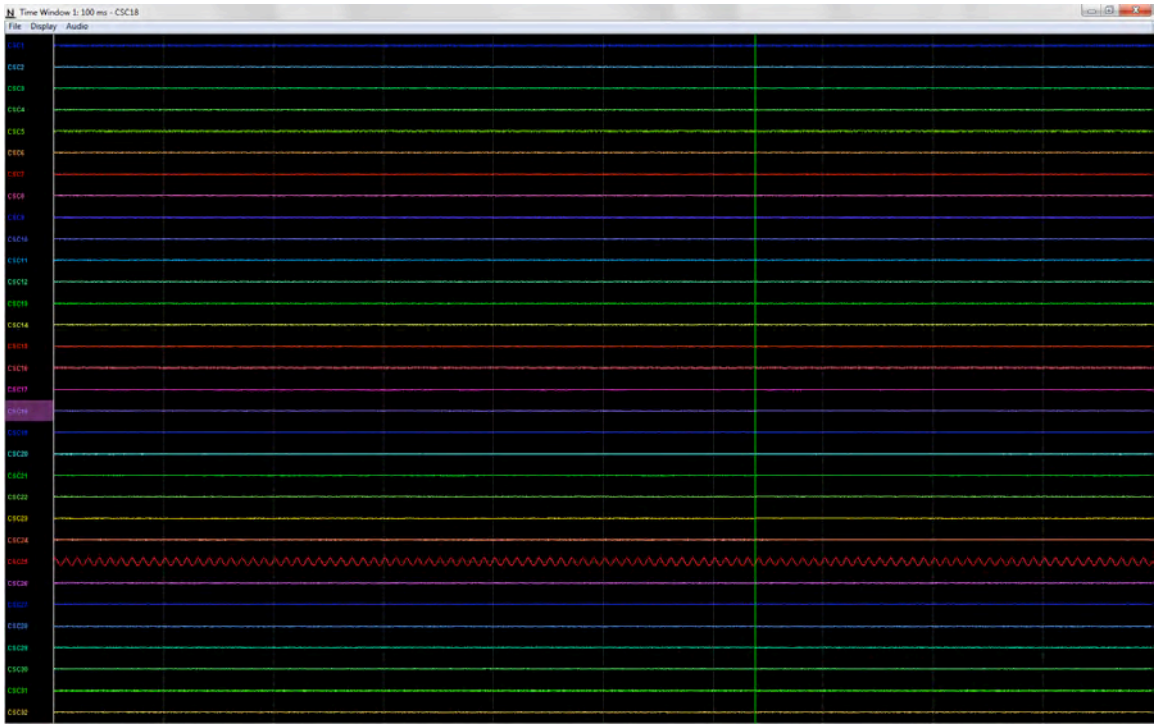


Figure 4-11 AC Current Waveform on Channel 25

The channels electrode impedance at 1kHz can be approximately calculated using the following equation.

$Z = V / I$
Z – Impedance of Electrode in Ω **V** – Voltage Amplitude Measured in Cheetah (Convert to Volts) **I** – Current Amplitude output of the AC Current Waveform Generator (Convert to Amps)

Figure 4-12 Channel Electrode Impedance Calculation

Once the impedance testing is complete the Impedance Measurement Function should be disabled. Once again this can be done with a Cheetah Configuration File.

Command Sequence:

1. Disable the Impedance Measurement Function.

Using the commands and syntax discussed in **Section 6 Multiplexing Headstage Command Descriptions** the following configuration file can be created.

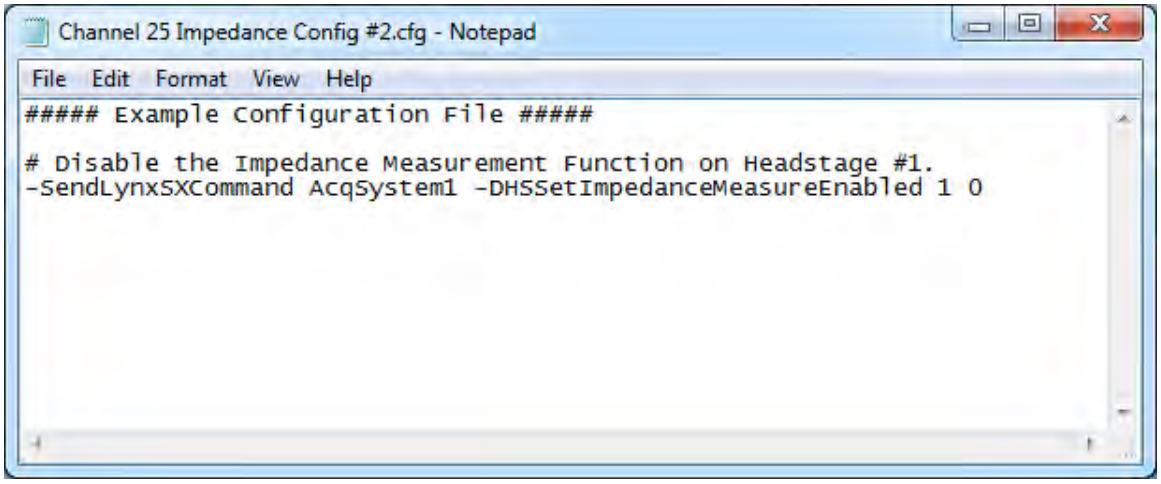

Channel 25 Impedance Config #2.cfg - Notepad
File Edit Format View Help
Example Configuration File
Disable the Impedance Measurement Function on Headstage #1.
-SendLynxSXCommand AcqSystem1 -DHSSetImpedanceMeasureEnabled 1 0

Figure 4-13 Example Configuration File

5 Hardware Overview

5.1 Multiplexing Headstage Amplifier and A/D Converter

Each AD Channel is digitized on the multiplexing headstage using a fixed reference. The channels are AC Coupled and the gain is fixed at 192 [V/V]. One 16 Bit A/D Converter digitizes 32 AD Channels. This concept is illustrated in the figure below.

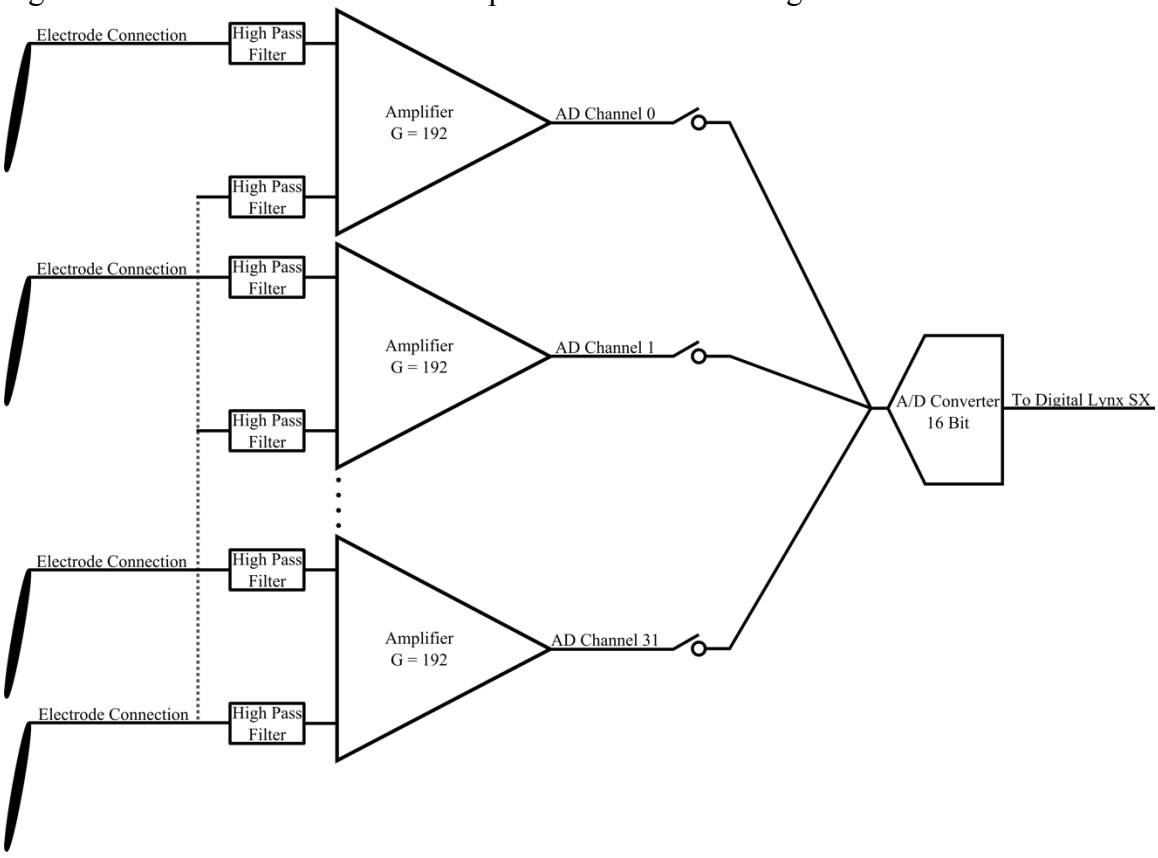


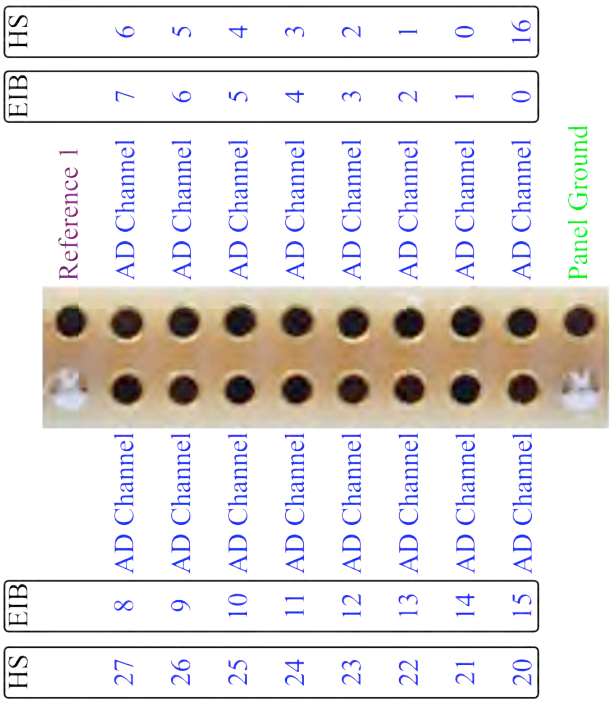
Figure 5-1 Multiplexing Headstage Hardware Illustration

5.2 Multiplexing Headstage Communication

The multiplexing headstage communicates with the Digital Lynx SX via a dedicated SPI Bus. Digital signals transfer data between the multiplexing headstage and the Digital Lynx SX. Digital signal quality degrades as cable length increases. For this reason it is recommended that the total cable length of the multiplexing headstage not exceed 4 meters.

5.3 Input Connectors

The pinouts for the multiplexing headstages are shown in the figures below.



18 Pin Female Nano Omnetics Connector

Figure 5-2 HS-16-mux headstage Input Pinout

Note: The HS-16-mux AD Channels do not match with the EIB AD Channels. A custom Cheetah Configuration File is required to properly map the AD Channels. An example configure file can be downloaded from neuralynx.com or the following outlined can be used. For further help with creating your own setup configuration files, please contact support@neuralynx.com.

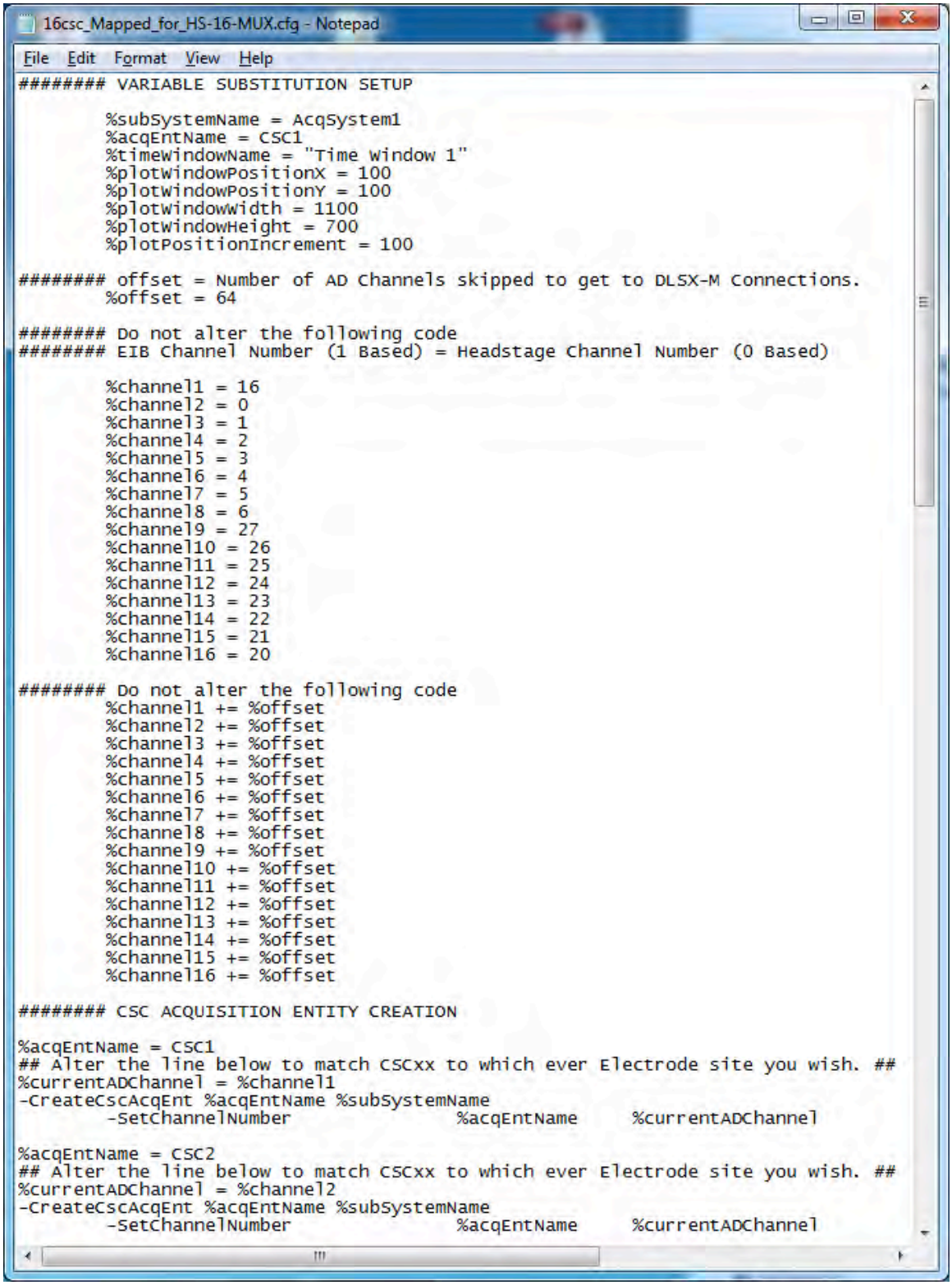
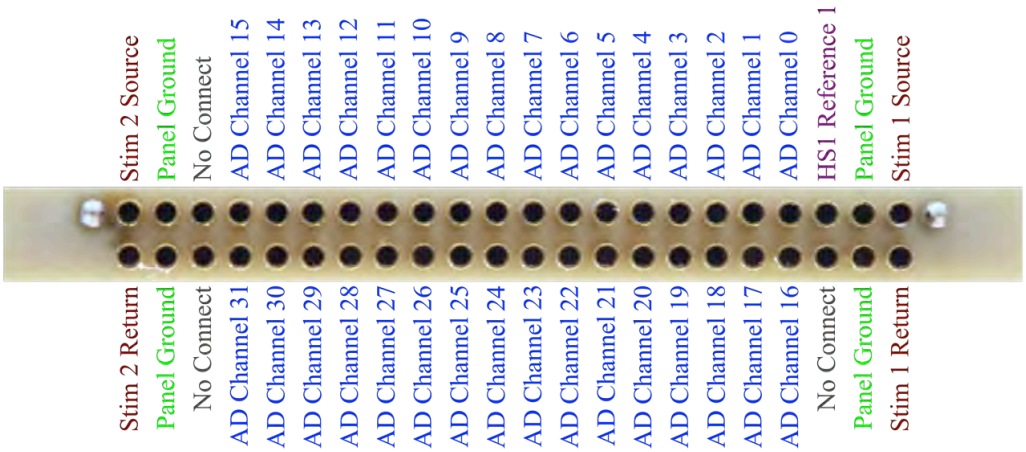
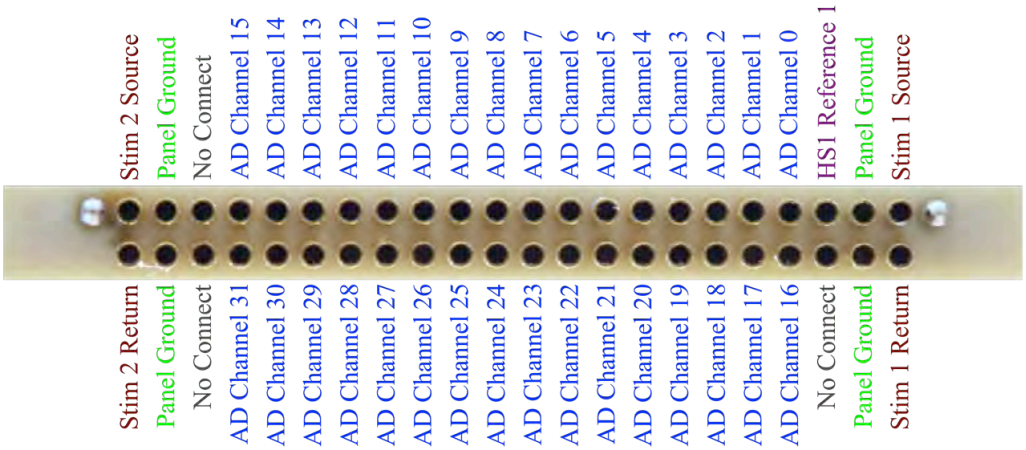

16csc_Mapped_for_HS-16-MUX.cfg - Notepad
File Edit Format View Help
######## VARIABLE SUBSTITUTION SETUP
%subSystemName = AcqSystem1
%acqEntName = CSC1
%timeWindowName = "Time Window 1"
%plotWindowPositionX = 100
%plotWindowPositionY = 100
%plotWindowWidth = 1100
%plotWindowHeight = 700
%plotPositionIncrement = 100
######## offset = Number of AD Channels skipped to get to DLSX-M Connections.
%offset = 64
######## Do not alter the following code
######## EIB Channel Number (1 Based) = Headstage Channel Number (0 Based)
%channel1 = 16
%channel2 = 0
%channel3 = 1
%channel4 = 2
%channel5 = 3
%channel6 = 4
%channel7 = 5
%channel8 = 6
%channel9 = 27
%channel10 = 26
%channel11 = 25
%channel12 = 24
%channel13 = 23
%channel14 = 22
%channel15 = 21
%channel16 = 20
######## Do not alter the following code
%channel1 += %offset
%channel2 += %offset
%channel3 += %offset
%channel4 += %offset
%channel5 += %offset
%channel6 += %offset
%channel7 += %offset
%channel8 += %offset
%channel9 += %offset
%channel10 += %offset
%channel11 += %offset
%channel12 += %offset
%channel13 += %offset
%channel14 += %offset
%channel15 += %offset
%channel16 += %offset
######## CSC ACQUISITION ENTITY CREATION
%acqEntName = CSC1
Alter the line below to match CSCxx to which ever Electrode site you wish.
%currentADChannel = %channel1
-CreateCscAcqEnt %acqEntName %subSystemName
-SetChannelNumber %acqEntName %currentADChannel
%acqEntName = CSC2
Alter the line below to match CSCxx to which ever Electrode site you wish.
%currentADChannel = %channel2
-CreateCscAcqEnt %acqEntName %subSystemName
-SetChannelNumber %acqEntName %currentADChannel

Figure 5-3 Example HS-16-mux Channel Mapping Configuration File

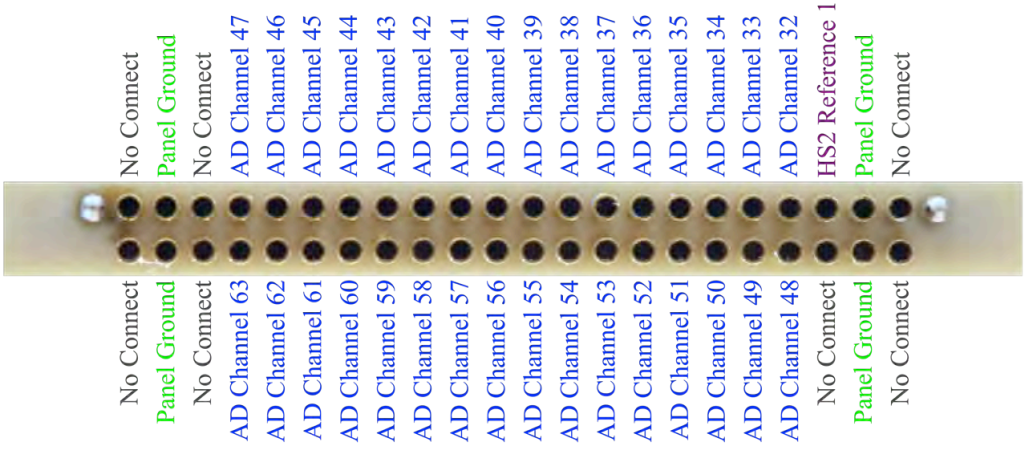


44 Pin Female Nano Omnetics Connector

Figure 5-4 HS-32-mux headstage Input Pinout



44 Pin Female Nano Omnetics Connector
Figure 5-5 HS-64-mux Input Pinout(1)



44 Pin Female Nano Omnetics Connector
Figure 5-6 HS-64-mux Input Pinout(2)

5.4 HS-36 Impedance Plug Resistance Values

The following figure contains the resistance values of each channel on the HS-36 Impedance Plug.

Channel	Resistance		Channel	Resistance
Reference 1	0Ω		Reference 2	0Ω
Channel 1	1MΩ		Channel 17	250kΩ
Channel 2	1MΩ		Channel 18	250kΩ
Channel 3	1MΩ		Channel 19	250kΩ
Channel 4	1MΩ		Channel 20	250kΩ
Channel 5	1MΩ		Channel 21	250kΩ
Channel 6	1MΩ		Channel 22	250kΩ
Channel 7	1MΩ		Channel 23	250kΩ
Channel 8	1MΩ		Channel 24	250kΩ
Channel 9	500kΩ		Channel 25	100kΩ
Channel 10	500kΩ		Channel 26	100kΩ
Channel 11	500kΩ		Channel 27	100kΩ
Channel 12	500kΩ		Channel 28	100kΩ
Channel 13	500kΩ		Channel 29	100kΩ
Channel 14	500kΩ		Channel 30	100kΩ
Channel 15	500kΩ		Channel 31	100kΩ
Channel 16	500kΩ		Channel 32	100kΩ
Reference 3	0Ω		Reference 4	0Ω

Figure 5-7 HS-36 Impedance Plug Test Value

5.5 HS-16 Impedance Plug Resistance Values

The following figure contains the resistance values of each channel on the HS-16 Impedance Plug.

Channel	Resistance
Reference 1	0Ω
Channel 1	1MΩ
Channel 2	1MΩ
Channel 3	1MΩ
Channel 4	1MΩ
Channel 5	500kΩ
Channel 6	500kΩ
Channel 7	500kΩ
Channel 8	500kΩ
Channel 9	250kΩ
Channel 10	250kΩ
Channel 11	250kΩ
Channel 12	250kΩ
Channel 13	100kΩ
Channel 14	100kΩ
Channel 15	100kΩ
Channel 16	100kΩ

Figure 5-8 HS-16 Impedance Plug Test Value

6 Multiplexing Headstage Command Descriptions

Commands can be sent to the multiplexing headstage through NetCom to configure certain settings on the headstage. These include; Impedance Functions and Fast Settle Functions. The following figures detail each command, how it is used, and its defaults. It is not necessary that these be used at any time.

-SendLynxSXCommand <Hardware Sub System Name> -DHSTriggerFastSettle <Headstage> <Bank>	
Triggers the Fast Settle Function. The Fast Settle Function can be used to reset the headstage when large input signals have caused amplifier saturation. The Fast Settle Function is approximately 300µs. Once this time has elapsed the Fast Settle Function is turned off.	
Example: -SendLynxSXCommand AcqSystem1 –DHSTriggerFastSettle 2 1	
Default: This command is an action, there is no default value.	
Usage: This Command can be used any time after acquisition has been started.	
Arguments:	
Hardware Subsystem Name	Name of sub system which will be controlled.
Headstage	This value can be one of the following keywords: **1**: Selects multiplexing headstage 1 as the command target. **2**: Selects multiplexing headstage 2 as the command target. **All**: Selects all multiplexing headstages as the command target.
Bank	This value can be one of the following keywords: **1**: Selects Bank 1 (first 32 channels) as the command target. **2**: Selects Bank 2 (second 32 channels) as the command target. **All**: Selects all Banks as the command target.

Figure 6-1 DHSTriggerFastSettle Command Syntax

-SendLynxSXCommand <Hardware Sub System Name> -DHSSetImpedanceMeasureEnabled <Headstage> <Value>	
Enables or disables the internal Electrode Impedance Measurement Circuitry on the HS-XX Digital.	
Example: -SendLynxSXCommand AcqSystem1 –DHSSetImpedanceMeasureEnabled 2 1	
Default: The internal Electrode Impedance Measurement Circuitry is by default disabled.	
Usage: This Command can be used after the Digital Lynx SX Hardware Sub System has been created.	
Arguments:	
Hardware Subsystem Name	Name of sub system that will be controlled.
Headstage	This value can be one of the following keywords: **1**: Selects multiplexing headstage 1 as the command target. **2**: Selects multiplexing headstage 2 as the command target.
Value	This value can be one of the following keywords: **1**: Enables the internal Electrode Impedance Measurement Circuitry. **0**: Disables the internal Electrode Impedance Measurement Circuitry.

Figure 6-2 DHSSetImpedanceMeasureEnabled Command Syntax

<table>
<tr><td colspan="2">-SendLynxSXCommand <Hardware Sub System Name> -DHSSetImpedanceMeasureCurrent <Headstage> <Value></td></tr>
<tr><td colspan="2">Sets the current that the multiplexing headstage will use for its internal Electrode Impedance Measurement Circuitry.</td></tr>
<tr><td colspan="2">Example: -SendLynxSXCommand AcqSystem1 –DHSSetImpedanceMeasureCurrent 2 3</td></tr>
<tr><td colspan="2">Default: The Impedance Measurement Current Value is by default set to 1, but the internal Electrode Impedance Measurement Circuitry is by default disabled.</td></tr>
<tr><td colspan="2">Usage: This Command can be used after the Digital Lynx SX Hardware Sub System has been created.</td></tr>
<tr><td colspan="2">Arguments:</td></tr>
<tr><td>Hardware Subsystem Name</td><td>Name of sub system that will be controlled.</td></tr>
<tr><td>Headstage</td><td>This value can be one of the following keywords:
1: Selects multiplexing headstage 1 as the command target.
2: Selects multiplexing headstage 2 as the command target.</td></tr>
<tr><td>Value</td><td>This value can be one of the following keywords:
<table>
<tr><th>Value</th><th>Current</th><th></th></tr>
<tr><td>1</td><td>0.128</td><td>nA</td></tr>
<tr><td>2</td><td>0.257</td><td>nA</td></tr>
<tr><td>3</td><td>0.385</td><td>nA</td></tr>
<tr><td>4</td><td>1.28</td><td>nA</td></tr>
<tr><td>5</td><td>2.57</td><td>nA</td></tr>
<tr><td>6</td><td>3.85</td><td>nA</td></tr>
<tr><td>7</td><td>12.8</td><td>nA</td></tr>
<tr><td>8</td><td>25.7</td><td>nA</td></tr>
<tr><td>9</td><td>38.5</td><td>nA</td></tr>
</table></td></tr>
</table>

Figure 6-3 DHSSetImpedanceMeasureCurrent Command Syntax

-SendLynxSXCommand <Hardware Sub System Name> -DHSSetImpedanceMeasureChannel <Headstage> <Value>	
Sets the channel that the multiplexing headstage will connect to its internal Electrode Impedance Measurement Circuitry.	
Example: -SendLynxSXCommand AcqSystem1 –DHSSetImpedanceMeasureCurrent 2 38	
Default: The Impedance Measurement Channel is by default set to 1, but the internal Electrode Impedance Measurement Circuitry is by default disabled.	
Usage: This Command can be used after the Digital Lynx SX Hardware Sub System has been created.	
Arguments:	
Hardware Subsystem Name	Name of sub system that will be controlled.
Headstage	This value can be one of the following keywords: **1**: Selects multiplexing headstage 1 as the command target. **2**: Selects multiplexing headstage 2 as the command target.
Value	This value can be one of the following keywords: **1-64**

Figure 6-4 DHSSetImpedanceMeasureCurrent Command Syntax

7 Glossary

CSC **–** Neuralynx acronym for Continuously Sampled Channel.
EIB **–** Neuralynx acronym for Electrode Interface Board.
Multiplexing Headstage (mux)– Headstage that digitized the physiological signals at the headstage. XX denotes the number of channels (ie. HS-32-mux digitizes 32 physiological signals).